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Editorial

Introduction to the selected papers from HES-2023 conference

The HES conference has always aimed to be a meeting point for different cultures, bringing together academic scientists and industrial professionals studying the application of electromagnetic fields for materials processing. After eight editions, the organisation of HES 2022 was particularly complex. In fact, in addition to the uncertainties still present in organising in-person meetings due to the pandemic, the impact of which was in any case diminishing, there was a serious international crisis caused by the war in Ukraine. The desire to organise an in-presence conference, and the desire to rejoin, after a long period of stalemate, the EPM scientific community, led the organisers to postpone the organisation of HES by a year. HES was scheduled to take place from 10 to 12 May 2023 in the enchanting venue of the historic Botanical Garden of the University of Padua, the symposium's organiser.

Despite a reduced attendance, the cultural climate was excellent.

The main developments in the area of electroheat is strictly related to the deep understanding of physical processes, which in turn is fostered by the multi-physics approach to modelling and simulation. In most applications, in fact, the solution of stand-alone electromagnetic or thermal problems is no longer sufficient, and a coupling among different physical domains is mandatory. In this respect, electromagnetics, heat transfer and thermodynamics, magneto-fluid dynamics, phase transitions, residual stresses, are considered as coupled domains in the contributed papers. Very many computational methods have been presented, but not all of them appear convenient enough for the use in practical engineering. In fact, technical and industrial challenges set some principal requirements and criteria for efficient computational methods. In this respect, the main task of a researcher consists of reducing the still intractable problems of field analysis and synthesis to the search for cost-effective approximate solutions based on friendly tools. One of the most current topics in the field of numerical modelling is the use of AI-based methods, both for solving direct and inverse problems. At the level of scientific research, but also in the industrial world, the use of methods such as digital twins, neural networks, and machine learning applied to electrothermal systems is finding increasing applications, and the first experiments presented in this area show enormous potential. For this reason, a special panel session dedicated to Artificial Intelligence and EPM was organised as part of HES23. Prof. Paolo Di Barba, University of Pavia, presented "The impact of machine learning on induction heating models (a personal view)"; Prof. François Bay, Ecole des Mines de Paris, "Multiphysics design and optimization of metallurgical processes – Induction heating of sutomotive parts"; Prof. Óscar Lucia (University of Zaragoza) "Artificial Intelligence for Power Electronics"; while Prof. Fabrizio Dughiero chaired the panel presenting "AI&Electroheat Technologies".

An important field of research presented at the conference is the electromagnetic processing of materials (EPM), where the electromagnetic field with different characteristics (high or low intensity, single or multi-phase, DC, AC, high or low frequency) is utilized to obtain materials with improved properties. The

research in more traditional fields, such as induction heating, is also moving towards new applications and asks for a deeper understanding of different phenomena during heat treatment processes. Several papers deal with home appliances of induction heating, with a special attention to increasing the efficiency and reducing the cost of induction systems; in this respect, top cooking is nowadays one of the most promising field of application.

As far as induction hardening is concerned, most of papers deal with multi-physics simulation of the process with the evaluation of temperature distribution, phase change during the process, hardening profiles, deformations and residual stresses. In turn, inverse problems in induction heating is another class of emerging topics: a typical issue is to synthesize the distribution of currents in the winding which give rise to a prescribed thermal profile along the workpiece. The exploitation of multi-objective optimization techniques and evolutionary computing algorithms help the solution of the inverse problem.

Specifically, 52 papers have been presented at HES23 by authors coming from 10 countries. The 10 papers selected for this special issue of IJAEM – *International Journal of Applied Electromagnetics and Mechanics* - after a peer review procedure, cover all the main topics presented at the conference. The editors would like to thank all the authors for their valuable contributions and, in particular, the editor-in-chief of the Journal for the opportunity of addressing a broader international audience.

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